Swelling and Solubility of Some Wild Yam Species Starch Granules

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Abstract

Starches extracted from the tubers of some wild yam species (Dioscorea praehensilis, D hirtiflora, D. bulbifera, D. burkilliana D. togoensis, D. dumetorum and D minutiflora) were studied with regard to their properties of swelling and solubility in the water. The hydration capacity of these starches was low. Their swelling corresponded to an absorption of water ranging between 5 g / g and 16 g/ g and their solubility is altogether limited enough ranging from 9.4% to 16.6% and occurred at elevated temperatures. The solubility increased with the swelling power.

***Keywords**:*

Starch; Tuber; Wild Yam; Swelling; Solubility

Introduction

Starch, a poly-saccharide extracted from various plants (Miche, 1974; Duprat et al, 1980; Leloup, 1990), resulting from chlorophyll synthesis with the main form in which plants accumulated energy reserves abounded in foodstuffs and was the predominant source of energy for humans (Miche, 1974; Buléon et al, 1990). At the native state, the starch was presented in the form of granules which had the aspect of an insoluble powder in cool water. The heating of a starch suspension, in excess water to higher temperatures at 50°C, involved an irreversible swelling of the granules and caused their solubilization (Leloup, 1990). The physicochemical properties of the yam and in particular the properties of the starch of yam which constituted one of the principal processed products of the yam were the object of many studies (Ozo et al, 1984; Trèche, 1989; Faboya and Asagbra, 1990; Farhat et al., 1999; Farombi et al., 2000; Brunnschweller et al, 2005).

The starch of yam with the characteristic to be locked up in mucilage required the recourse to the processes of extraction per enzymatic way as well as high manufacturing costs. The usual processes caused the impurity of starches especially rich in proteins (UNIFEM, 1989).

The food-processing industry used different poly-saccharide in nutritional purposes to improve or modify the rheological properties of finished products (Mestres et al, 1988). Thus mainly poly-saccharide of origin vegetable was found that could express properties stabilization, thickening and gelling (Farombi et al, 2000; Brunnschweller et al, 2005). Our study here focused on wild yam starch. These included species: Dioscorea praehensilis, D. hirtiflora, D. bulbifera bulbil, D. bulbifera tuber, D. burkilliana, D. dumetorum, D. togoensis and D. minutiflora, commonly found in the Ivorian forest. Starches of these Dioscorea species were studied with respect to their swelling properties and solubility in water according to the temperature. Our study contributed to the research of the tropical polymers that would be likely to have properties similar to the modified starches.

Material and Methods

Vegetable Materials

Vegetable material is constituted by the starch of some wild yam tuber. The tubers were collected in the South of Ivory Coast forest zones, in particular at Memni region, 80 km of Abidjan, in July and August, 2002. Samples were identified by Abidjan University Cocody floral Institute. The tubers were Dioscorea praehensilis, D hirtiflora, D. bulbifera, D. burkilliana D. togoensis, and D.dumetorum and D minutiflora. Before the tubers processing two days after each collection they were preserved at the room temperature in jute bags at the laboratory (Amani et al, 1993).

Extraction of Starch

The starch was extracted two days after the yam tubers were collect according to an adaptation of the method described by Delpeuch et al (1978).

"**2** to 3 kg of tubers of yam species were washed and peeled. To avoid that the pulp of yam does not brown,

by oxidation in contact with oxygen of the air, it is plunged in some water where an antioxidant (0.10 % dioxide of sulphur) was added beforehand. The pulp of yam was then reduced in paste in a propeller crusher and to eliminate proteins from the paste obtained, and dispersed in a solution of 4% NaCl before being pressed in a bag made in a tissue.

The milk of starch extracted was collected in a basin and then passed successively through 500 µm; 250 µm and 100µm sieves. The remaining solids, which constituted the starch, was decanted and washed with distilled water at least four times and then dried at 45°C for 48 h. This starch obtained was conditioned in jars and kept in the refrigerator until the use.

Swilling and Solubility Test of the Starch

The test of swelling and solubility is realized according to an adaptation of the method of Leach et al (1959). A suspension of starch in 1% p/v is prepared and put in the bain-marie with various temperatures (55°c-95°c) in intervals of 5°C under maximal excitement during 30 minutes, then spin-dried in 5000 trs/min during 15 min. Nerves and supernatant are collected in different aliquots.

The quantity of water retained by the sample is obtained by making the dry material on the aliquots of the nerve. The swelling is estimated by the quantity of water retained by the sample after centrifugation, in grams of a water / gram of starch. The quantity of solubilized starch is obtained by making the dry material floating. The solubility, the dissolved quantity of the sample in the water over time given to a supposed temperature, is expressed in Percentage of starch.

Results

The evolution of swelling in aqueous according to the temperature of starches studied is represented on the Figure 1. The swelling reflected the hydration capacityof the starch insoluble fraction in water and expressed in grams of water absorbed per gram of insoluble fraction.

The equations of the starches swelling curves and their determination coefficients are indicated in the Table 1.

The evolution of the starches swelling is done in the following order: D. burkilliana < D. dumetorum < D. hirtiflora < D. bulbifera bulbil) < D.bulbifera tuber) < D. togoensis < D. minutiflora < D. praehensilis (Table 1).

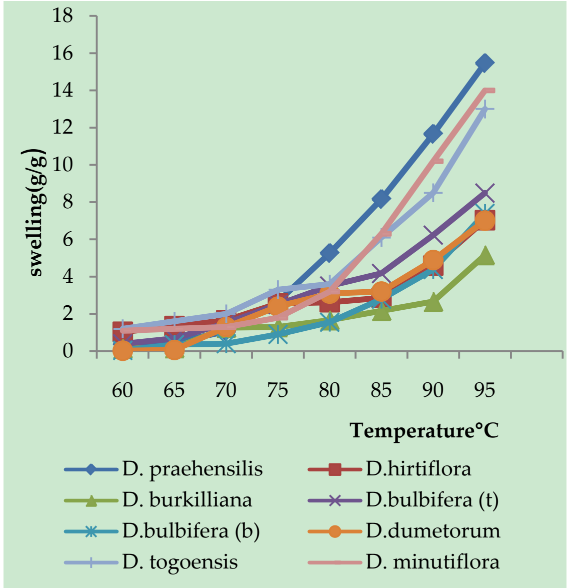

FIG 1: STARCHES SWELLING CURVES

TABLE 1: EQUATIONS OF THE SWELLING CURVES

Starch	Equations	Determination Coefficient
D.praehensilis	Y=1.4495X	R^2= 0.7798
D.minutiflora	Y=1.2343X	R^2= 0.7191
D. togoensis	Y=1.1848X	R^2= 0.795
D. bulbifera	Y=0.8348X	R^2= 0.865
D.dumetorum	Y=0.6791X	R^2= 0.8463
D. hirtiflora	Y=0.6743X	R^2= 0.8207
D. bulbifera bulbil	Y=0.5873X	R^2= 0.6765
D. burkilliana	Y=0.4439X	R^2= 0.7679

The evolution of solubility in aqueous according to the temperature of starches studied is represented on the Figure 2. The solubility is expressed in percentage of starch solubilized.

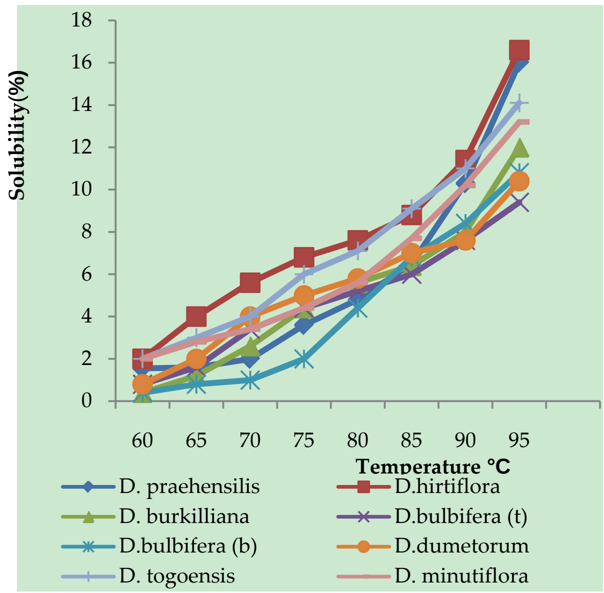

FIG 2: STARCHES SOLUBILITY CURVES

The equations of the starches solubility curves and their determination coefficients are given in the Table 2.

TABLE 2: EQUATIONS OF THE SOLUBILITY CURVES

Starch	Equations	Determination Coefficient
D. hirtiflora	Y= 1.752X	R^2= 0.9163
D. togoensis	Y= 1.5877X	R^2= 0.9691
D. praehensilis	Y= 1.413X	R^2= 0.7676
D. minutiflora	Y= 1.4049X	R^2= 0.9162
D. burkilliana	Y= 1.2088X	R^2= 0.9025
D. dumetorum	Y= 1.1971X	R^2= 0.9721
D. bulbifera tuber	Y= 1.0892X	R^2= 0.9787
D. bulbifera bulbil	Y= 1.0833X	R^2= 0.8239

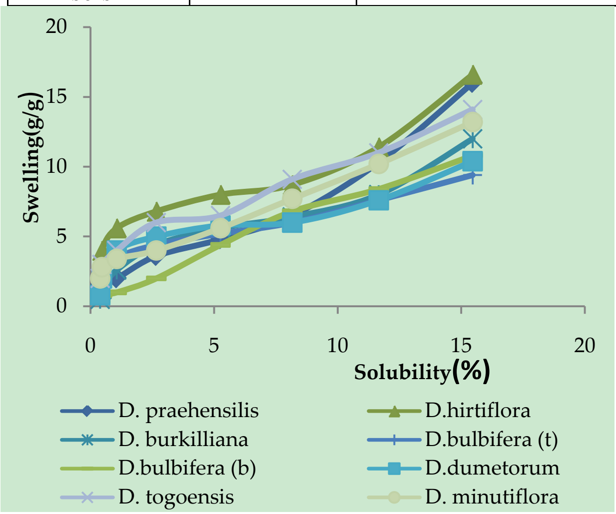

FIG 3: CURVES OF SWELLING ACCORDING TO THE SOLUBILITY

TABLE 3: EQUATIONS OF THE CURVES OF SWELLING ACCORDING TO THE SOLUBILITY

Starch	Equations	Determination Coefficient
D. hirtiflora	Y=1.1078X	R^2= 0.6107
D. togoensis	Y=0.9985X	R^2= 0.7251
D.praehensilis	Y=0.9602X	R^2= 0.9515
D.minutiflora	Y=0.9033X	R^2= 0.8315
D. burkilliana	Y=0.7863X	R^2= 0.8741
D.dumetorum	Y=0.7276X	R^2= 0.5645
D. bulbifera tuber	Y=0.6836X	R^2= 0.6606
D. bulbifera bulbil	Y=0.7335X	R^2= 0.9858

The curves of swelling according to the solubility equations and their determination coefficients are indicated in the Table 3.

The evolution of the solubility is done in the following order: D. bulbifera bulbil) < D.bulbifera tuber).

<D dumetorum < D. burkilliana < D. minutiflora <D. togoensis < D. praehensilis<D. hirtiflora: (table 2).

The evolution of the swelling according to the solubility is represented in Figure 3.

Discussion

Swelling of starches studied is varied according to the species (Figure 1). The equations of swelling curves (Table 1 indicated two groups of starches:

The group which contained starches extracted from yam species D. praehensilis, D togoensis and D. minutiflora.

Starches of this group had curves of swelling with slope > 1 (Table 1) and their capacities of hydration are relatively more improved in 95°C: 15.46 g/g (D. praehensilis); 14 g/g (D. minutiflora); 13 g/g (D. togoensis) (Figure1).

The group which contained starches extracted from yam species D.bulbifera tuber, D. bulbifera bulbil, D.dumetorum, D. burkilliana and D. hirtiflora.

Starches of this group had curves of swelling with slope < 1 (Table 1) and their capacities of hydration are less improved in 95°C: 8.49 g/g (D. bulbifera tuber); 7.39 g/g (D. bulbifera bulbil); 7.03 g/g (D. hirtiflora); 7.01 g/g D.dumetorum; 5.16 g/g (D. burkilliana) (Figure 1).

Hydration capacities of the whole studied starches were poor compared with those of the starches extracted from the plantain 36.0 g/g (Gnakri and Kamenan, 1994) and from the wild yam D. abyssinica 23 g/g (Hoover, 2000).

These starches onset temperatures of swelling around 65°C to 75°C were relatively high (Figure 1), indicating that these starches were heat resistant.

As in the case of swelling, the solubility of the starches studied is varied with the species (Figure 2). Solubilities at 95°C of different starches studied were respectively: 16.6% (D. hirtiflora), 16% (D. praehensilis) 14% (D. togoensis) 13.2% (D. minutiflora), 12% (D.burkilliana) 10.8% (D. bulbifera bulbil) 10.4% (D. dumetorum) and 9.4 (D. bulbifera) (Fig. 2).

The solubility curve equations had almost identical slopes ranging from 1 to 2 (Table 2). This explained the insignificant differences between the values of solubilities. The wild yam D. abyssinica starch solubility found by Hoover (2000) would be in this range. The solubilities of the starches, overall low, occurred at high temperatures about 70° C to 75°C (Figure 2). These starches were heat resistant.

The swelling and the solubility of the starch can be influenced by various factors; in particular the presence of lipids in the starch, in which they were tended to be reduced, lipids established connections with the amylose and increased its molecular mass which caused the blocking of the binding of water molecules, preventing the swelling of the granule and the distribution of the amylose outside this one (Meredith et al, 1978; Hoover and Hadziyev, 1981; Swinkel, 1985; Bjork et al, 1990). An ash content of starches would be considered as an indication of the quantity of groupings phosphates, which could also raise the inflation of starches (Swinkel, 1985). The curves of swelling according to the solubility (Fig. 3) indicated an increase of the solubility according to the power of swelling.

The comparison of the starches swelling and solubility curves indicated a narrow relation between both functional properties of starch. This link of correlation was confirmed by the coefficients of determination R^2 respective of the starches (Table 3). The values of R^2 were close to 1, indicating that there was a positive correlation between solubility and swelling starches. This finding of the existence of correlation between the two properties of starches is in agreement with that of Delpeuch and Favier (1980) on tropical tuber starches, Gnakri and Kamenan (1994) on plantain starch.

Conclusion

The starches extracted from these studied tubers of wild yam are heat-resisting and would be a good texture agent of the manufactured goods at high temperature, like highly stabilized and sterilized products.

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